Remarks by

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at the

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EXPANDING THE USES OF SPACE -- 1974 THRU 1991

The National Aeronautics and Space Administration has a strong, realistic, and highly rewarding national space effort planned for this decade and the next.

Our long-range planning efforts -- and indeed our spirits -- have been greatly bolstered in 1973 by the excellent results we are getting from a wide variety of current programs. Programs such as

-- Skylab, Man's first home in space and, I believe, the most productive satellite of our era;

-- or the Pioneer 10 now stirring the imaginations of millions of people around the world as it approaches the giant planet Jupiter;

-- or our first Earth Resources Technology Satellite, ERTS-1, which among other unprecedented achievements has given us new confidence in our ability to protect the environment of our home planet Earth;

-- or our most ambitious scientific satellite to date, the Orbiting Astronomical Observatory named for Copernicus (OAO-3), which has recently produced evidence of the existence of a Black Hole in the universe, and pinned down its location.

These current achievements give you some idea of the broad range of NASA's activities today -- activities which range through the spectrum of modern scientific endeavor, from measuring the drifting apart of the continents at about one inch per year to searching for life elsewhere in the solar system.

To help bring some order into my presentation of such a broad and varied effort, I would like to invite your attention to four major goals we are currently pursuing:

One. We are expanding our use of automated spacecraft in Earth orbit for scientific and practical benefits.

Two. To support this effort, and reduce its cost, we are developing the Space Shuttle in this decade and will use it in the Eighties and Nineties as an economical and versatile transportation system to take satellites to Earth orbit and back. Thus the reusable Space Shuttle will replace our present expendable, one-way launch vehicles (except perhaps the smallest, the Scout rocket).

Three. Beginning in 1980, we expect to make extensive use of a manned Spacelab module which will be carried to orbit and back by the Space Shuttle for a wide variety of carefully controlled experiments and observations.

Four. While concentrating on activities in Earth orbit, we will also continue our strong, methodical effort to send unmanned spacecraft to explore throughout the solar system and search for extraterrestrial life. This effort to explore the planets and fly in close to the Sun is already well underway.

We have just recently completed an important new planning exercise at NASA. We have drawn up what we call a NASA payload model which shows with some precision the number of payloads, and the kinds of payloads, we might reasonably expect to send to Earth orbit and farther out into the solar system each year from now through 1991.

Our planning that far ahead is still quite tentative, as it should be, but I can still give you a good idea of the shape of the future in space through 1991. And we have been quite realistic about the cost, because the NASA payload model I am talking about assumes a level of expenditures at about the current level -- that is, around $3.2 or $3.3 billion dollars per year, adjusted as necessary for inflation.

So let's take a look at what we are doing to explore and use space today and then see where this is likely to lead during the next two decades.

I will start with our currently approved programs to explore the planets, because we are expecting exciting developments as Pioneer 10 swings by Jupiter during the next few days.

Pioneer 10, as you may know, was launched toward Jupiter on March 3, 1972, and has already travelled more than half a billion miles. It is the first spacecraft to be sent from Earth toward the Outer Planets, and the first to fly through the Asteroid Belt between the orbits of Mars and Jupiter.

One of the first important findings of Pioneer 10 has been that the asteroid belt is not a significant hazard to navigation. Despite some early fears on this subject, we are definitely not walled in from the Outer Planets. This finding, and Pioneer's continued flight, give us an expanding view of where we live and what our environment is. I believe it is going to become quite natural, in the years ahead, to think of ourselves as inhabitants of the solar system, rather than just of Earth.

Pioneer 10 has travelled farther from the Earth and flown faster than any other man-made object. Its speed at launch had to be more than 32,000 miles per hour. That is why we were already 15 years into the Space Age before the first voyage to the Outer Planets was attempted. Significant advances had to be made in spacecraft and rocket technology and space communications before a spacecraft like Pioneer 10 could be launched. For example, it flies so far from the Sun that it cannot rely on the solar cells used to provide electrical power for other spacecraft. It is the first NASA spacecraft to rely solely on nuclear energy for the electrical power needed for its communications equipment and other instruments.

Pioneer 10's closest approach to Jupiter will be on next Monday, December 3, at 9:26 p.m. Eastern Standard Time when it will come within about 81,000 miles of Jupiter's cloud tops.

As Pioneer 10 nears Jupiter, the planet's gravity will increase its speed until it is going 82,000 mph at periapsis, or closest approach. This high speed will enable it to escape entirely from the gravitational fields of the solar system and wander forever among the stars. We hope to be able to communicate with it out to the orbit of Uranus, which it will reach in 1979, when it is 1.8 billion miles, or 160 light minutes, from the Sun.

Reports from Pioneer 10 are being received at the three large antennas in NASA's Deep Space Network. These antenna are located at Goldstone, California, and in Australia and Spain. Thus we can always keep one antenna trained on Pioneer despite the rotation of the Earth.

We are all very much interested, of course in Pioneer 10's chances for survival as it passes through the magnetic fields of Jupiter.

I received the following up-to-the-minute report from Ames Research Center just before noon today.

Pioneer 10 entered Jupiter's bow shock wave on Monday while the spacecraft was approximately five million miles from the planet. This event occurred somewhat earlier than expected and indicates a very strong magnetic field is present around Jupiter.

Pioneer 10's passage of the magnetopause -- that is, the actual entry into Jupiter's magnetic field -- also occurred earlier than expected. That was on Tuesday afternoon, so Pioneer has been in the Jovian magnetic field for two days now.

Based on these early crossings, we are able to predict that electron energy levels in the vicinity of the spacecraft will be somewhat less than previous estimates. However, it is still too early to predict proton energy levels.

So you might say, it's still touch and go for Pioneer 10. The uncertainty may continue up through Monday.

In the meanwhile, Pioneer 10 is performing admirably, and is now sending back some very interesting pictures of Jupiter, including definition of colorful bands around the planet and the well-known giant red spot.

Some of the more recent pictures also show images of several of the larger moons of Jupiter, the so-called Galilean satellites. They were discovered by Galileo shortly after he invented the telescope.

Today Jupiter appears about the size of a baseball on the TV screens at Ames Research Center. These images will continue to grow, and will more than fill the TV screens by Monday.

It has been anticipated that by some time Saturday the pictures received from Pioneer 10 would begin to be better than the best obtainable from Earth-based telescopes.

Pioneer 10's sister spacecraft, Pioneer 11, is also on the way to Jupiter. Pioneer 11 was launched on April 6 of this year and will encounter Jupiter in December of 1974. We are counting on data from Pioneer 10 to determine if we can send Pioneer 11 much closer to Jupiter's cloud tops. If we think it safe to send Pioneer 11 as close as 20,000 miles to Jupiter, there will be a special bonus. Pioneer 11 will then pick up enough speed to fly close by Saturn, and become the first spacecraft from Earth to visit that distant planet.

Our next spacecraft to visit the Outer Planets, after Pioneer 10 and 11, will be two larger Mariner-type craft, which will be launched toward both Jupiter and Saturn in 1977. These Mariner spacecraft will weigh about 1650 pounds each, compared with only 570 pounds for Pioneers 10 and 11. They will pass at a considerable distance from Jupiter (more than 200 thousand miles) but will come within about 72,000 miles of Saturn. An especial effort will be made to learn more about Saturn's rings and about the moons of Saturn, including the big one named Titan, which appears to be one of the most interesting bodies in the solar system. At least it appears to have an atmosphere and atmospheric temperatures which might make it what has been called a "laboratory for organic chemistry and a place to study prebiological organic evolution." But as I indicated, these Mariner spacecraft will not be launched until 1977 and will not reach the vicinity of Saturn until about 3 1/2 years later. That would be in 1980 or 81.

Another planetary event of more immediate interest is the current flight of Mariner 10, which was launched on November 3 and is now enroute to fly-by Venus and Mercury. Mariner 10 will be the first spacecraft to approach Mercury -- the innermost planet -- and will come quite close, within about 625 miles of the surface. Mariner 10 will use the gravity pull of Venus to direct it on toward Mercury. It will be the first spacecraft from Earth to use this energy-saving kind of maneuver to reach another planet. Many TV pictures will be taken of the cloud systems of Venus and the sun-scorched surface of Mercury.

What promises to be our most important planetary missions in this decade, according to presently approved plans, are the two flights by Viking spacecraft to Mars. These large advanced Viking spacecraft, weighing 8,100 pounds each, will be launched in 1975. Each Viking consists of two major parts -- an Orbiter and a Lander. While the Orbiters relay communications with Earth and gather other data, the Landers will touch down softly on the Martian surface, transmit TV pictures, and deploy instruments to search for evidence of extraterrestrial life.

It just so happens that the celestial mechanics involved, and the scheduling dictated by budgetary considerations, will permit one of the Vikings to land on Mars on or about the Fourth of July 1976, on the 200th anniversary of American independence.

We hope our Viking landers will be the first to discover uncontestable evidence of life elsewhere in the solar system. But this honor may go to the Russians.

As you probably know, the favorable opportunities to send spacecraft to Mars come at about two-year intervals. We have passed up the opportunity to launch spacecraft to Mars this year, but the Russians have not. The Soviet Union now has four spacecraft enroute to Mars. They are due to arrive in February and March.

Four spacecraft to Mars at one time may seem like a lot, but two of them appear to be orbiters and two landers. So in terms of quantity, these four are no more than our two Vikings, since each Viking consists of both an Orbiter and a Lander.

We do not know exactly what experiments the Soviet Mars landers are supposed to carry out on the surface. But even if the Russians do not find evidence of life on Mars in 1974, they will have another opportunity in 1976, when our Vikings are due to land.

Regardless of which national space team is first to find life on Mars or elsewhere in the solar system, it will be a great triumph for mankind and, what is more important, will certainly stimulate interest in space exploration. I hope it will also facilitate the current trend toward greater cooperation on major undertakings of this kind.

Our approved plans for exploration of the solar system in this decade already include an important international cooperative effort to observe the Sun itself from close range, the Helios program.

Now let us look beyond the presently approved planetary programs to see what are some likely missions later in the decade and in the 1980s. Our latest planning document, called the 1973 NASA Payload Model, was completed last month. It describes in some detail the most likely payloads we could send to the planets or Earth orbit between now and 1991 without significant increases in our annual budget.

According to these plans, which are of course tentative, and not approved by NASA, the President, or the Congress, we might launch another Viking to Mars in 1979, two new spacecraft to bring back surface samples from Mars in 1984, and two similar spacecraft to bring back samples from the two moons of Mars, Phobos and Deimos, in 1990 and 1991.

According to our current Payload Model document, we might also resume exploration of Venus with two Pioneer spacecraft in 1978, which would send down a number of widely scattered atmospheric probes. By 1983 we might be ready to send two spacecraft to orbit Venus at a low altitude of 270 miles and map the surface by radar. By 1985 we might send two spacecraft to float in the Venus atmosphere at various levels, and in 1989 we might send a Large Lander to Venus to take TV cameras and other instruments to the surface. By 1987 we might launch two spacecraft to orbit Mercury. One would be in circular orbit at 270 miles and one in elliptical orbit going as close as 110 miles.

According to the same planning document, we could proceed to explore the Outer Planets in the same methodical way, redefining missions as required to take advantage of unexpected opportunities.

As I mentioned earlier, our only approved program to visit the Outer Planets after the current Pioneer flights calls for launching two Mariner-type craft in 1977 to fly by Jupiter and Saturn. Continuing this line of attack we might launch as many as 10 Mariner or Pioneer spacecraft to the Outer Planets in the 1980s, including flybys of Uranus and Neptune, probes into the atmospheres of Jupiter, Uranus, and Saturn, and orbiters around Jupiter and Saturn. And in 1990 and 1991 we might send two very heavy spacecraft weighing 21,000 pounds each to orbit one of Jupiter's moons at an altitude of only 55 miles, and land an instrument package, including a TV camera, on this Jovian moon.

The scientific community also gives high priority to sending unmanned spacecraft out to investigate comets and asteroids during the next two decades. For example, a small spacecraft weighing about 1,000 pounds might be launched in 1976 to take advantage of an opportunity to fly by two known comets. And in 1979 a much heavier spacecraft, weighing about 4,500 pounds, could be sent to make a slow flyby of the Comet Encke, coming within 2,700 miles of the comet's nucleus. Two years later, in 1981, a similar spacecraft might rendezvous with the Comet Encke, coming within 55 miles of the nucleus. A TV camera might be included among the many instruments on this flight.

Then, in 1985, will come the opportunity for a close-up view of the best known comet of them all, Halley's Comet, which makes its spectacular appearance every 74 to 79 years. Each appearance of Halley's Comet has been observed since 240 B.C. Now we will have the opportunity to observe it at very close range for the first time, with a full complement of modern instruments. It is proposed to fly an unmanned satellite within about 5,500 miles of the nucleus of Halley's Comet. This would be in 1985.

Our first close-up observation of asteroids might be made from two spacecraft launched toward the Asteroid Belt in 1986. They would be expected to send back TV pictures and other data from very close range -- from distances measured in feet rather than miles. Or, since this is going to be in 1986, perhaps I should say from distances measured in meters, not kilometers.

As you may have noticed, there is no mention of manned missions to Mars in this projection. I believe you can see why, because there are so many preliminary missions of great scientific importance to be undertaken first. I personally do not foresee the beginning of a specific approved program to send men to Mars before the 1990s, and I would guess that even then it would have to be a major international undertaking. It would probably be too expensive for one country alone. But we should avoid making firm predictions about the schedule for manned missions to Mars at least until we see what results come back from the Viking landings in 1976.

At this point, you may be wondering, what are our plans for returning to the Moon? We are, of course, very busy analyzing the soil samples and rocks returned from the Moon in the Apollo program, and the many pictures and other data obtained by the Apollo astronauts, or sent back by the instruments the astronauts placed on the Moon.

Five different Apollo crews placed Lunar Surface Experiment Packages on the Moon, and at least some of the experiments in each of these five packages are still sending back useful data. The design life of these experiments was only one year, but the first, put in place by the Apollo 12 crew, has been operating for more than four years now. These experiments have a nuclear power supply -- or to be more precise, radio isotope thermoelectric generators. Pioneer 10 carries similar generators.

Hundreds of scientists in the United States and abroad are working on the lunar samples. It is estimated that it will take these scientists more than 10 years to complete their studies of these samples. University scientists are playing an important role in this work. 133 principal investigators from 59 universities are analyzing lunar samples.

Twenty-seven of the experiments left on the Moon in the Apollo program were conceived by university investigators, including scientists here at the University of Maryland. I might also point out at this time that 17 of 71 Skylab experiments were developed by university investigators, and 102 principal investigators from universities are participating in the Earth Resources Technology Satellite program.

We have no currently approved plans to send either manned or unmanned spacecraft back to the Moon. However, in our tentative payload projection through 1991 we do suggest sending eight automated spacecraft to the Moon. These include a Lunar Polar Orbiter in 1979; two other Lunar Orbiters in the 1980s; two Lunar Rovers in the 1980s which would travel as far as 60 miles during a year on the lunar surface; a so-called Lunar Halo Satellite which would assure communications with the hidden side of the Moon from an altitude of about 35,000 miles above the Moon (at one of the libration points); and finally, in 1990 and 1991, two Lunar Rovers which could return lunar samples to Earth from any point on the Moon. To date, of course, no samples have been returned from the hidden side of the Moon.

By 1990, if not long before, we will surely want to consider the desirability of establishing one or more large manned scientific stations on the Moon. I would like to see this undertaken as an international project.

Now we could spend the rest of the afternoon discussing present and future flights to the Moon and planets, but I think we had better come back to Earth orbit where, as I said, most of the space action is going to be over the next two decades.

For example, the latest NASA Payload Model (still quite tentative, of course) shows 56 payloads going to the Moon and planets between 1974 and 1991 compared with 744 payloads destined for Earth orbit.

That averages out to three payloads per year to the Moon and planets and 41 to Earth orbit, a ratio of 1 to 14.

Payloads in Earth orbit include 408 automated (unmanned) payloads and 336 to be carried in the manned Spacelab module. The latter are called "sortie" payloads.

The figures for Earth orbit include payloads launched by NASA for other government agencies, for foreign agencies, and for commercial organizations, such as Comsat Corporation. The payload figures do not include Department of Defense payloads.

We cooperate closely with the Department of Defnese to avoid wasteful duplication of effort and to share facilities, technology, and experience, but the military and civilian space programs are kept separate, and rightly so, as stipulated in the National Aeronautics and Space Act of 1958, which created NASA.

Many successful satellites in Earth orbit have already shown us the potential long-range opportunities there for science and practical benefits. And Skylab has proved that men can live there for long periods, and work effectively as scientists and engineers.

So we now know, without question, that Earth orbit is a new frontier of great promise for all mankind. Only one thing is holding us back. It is difficult and costly to get to Earth orbit and back with present day rocket technology. The completion of the Space Shuttle in 1979 will change all that.

The reusable Space Shuttle, as many of you may know, is one of the truly ingenious inventions of this inventive century. It is more than a new kind of launch vehicle. We call it a Space Transportation System.

The main part of the Shuttle system is the Shuttle Orbiter. It will take off vertically, assisted by two booster rockets which will drop off into the ocean and be recovered. The booster rockets use solid fuel, the Shuttle burns liquid oxygen and hydrogen. The oxygen and hydrogen fuel will be carried in a large tank attached to the Orbiter. The fuel tank will be discarded after orbit is reached; the tank will descend into a remote ocean area and will not be re-used.

The Orbiter can remain in space for up to 30 days. Then it will return to Earth and land on a runway like an airliner. It can be quickly prepared to return to space, and is designed to fly one hundred times or more. The Shuttle Orbiter will have a crew of three astronauts, with an extra crewman to help handle automated payloads.

In short, the Space Age will really begin when the Shuttle flies.

As our plans for the Shuttle took shape, we found that it will not only provide routine and economical access to Earth orbit. We also found that Shuttle use will greatly reduce the cost of building the payloads it carries. No longer will every satellite have to be custom designed to save space and weight. Standard designs and standard components and sub-systems can be used. Because payloads can be checked out and repaired in orbit, or brought back to Earth, expensive redundant systems can be eliminated. And the stresses and strains of launch will be much less with the Shuttle than with today's one-way rockets.

As the Shuttle design effort continued, there was a surprise benefit. We realized we could easily make the Shuttle serve many of the same purposes as a manned Space Station. We found that the cargo compartment of the Shuttle, designed to handle large unmanned spacecraft, could also accommodate pre-fabricated manned space laboratory modules, and scientists could go into orbit with their experiments. The cargo compartment of the Shuttle is 65 feet long and 15 feet in diameter. You can get quite a large laboratory into that space. The Spacelab modules will be designed so they can be quickly inserted or removed from the Shuttle.

The availability of the Spacelab will be a boon to scientists in many disciplines, and especially to university scientists. No longer will it be necessary to design a special spacecraft and many special instruments for each experiment. No longer need there be long delays between the time when an experiment is conceived and when it is finally flown in space. No longer will scientist teams work for years on a project and then see it destroyed during launch or disabled by a simple malfunction in orbit.

The Space Shuttle and the Spacelab module have really put an end to the argument about whether we should use manned or unmanned spacecraft in Earth orbit. We can now have the advantages of both, and eliminate the disadvantages.

Just recently we signed an agreement with a group of nine European countries under which they will design, develop, and manufacture the manned Spacelab module. The Europeans will pay the cost, estimated to be between $350 and $400 million. They will deliver one Spacelab module to NASA without cost to us. We will also buy additional Spacelab modules for use in the period 1980-1991. We will be able to purchase these additional Spacelabs from the Europeans at a fair price, which would not include amortization of the cost of development. In return, the Europeans will gain from working closely with us on the Spacelab design and development. And they will also be able to call upon us for Space Shuttle launch services at reasonable cost, and of course their scientists will also fly on some of the Spacelab missions.

What will the Shuttle payloads be like? I think they will match the ingenuity of the Shuttle. Here are some examples, based on tentative plans:

-- In the Astronomy Program there will be a Large Space Telescope, weighing 11 tons, with a lens 120 inches in diameter. It will be launched by the Shuttle and then re-visited by Shuttle crews at yearly intervals. It will also be brought back to Earth by the Shuttle after a number of years, refurbished, and carried back to orbit.

-- In the Astronomy Program there will also be large High Energy Astronomical Observatories, Large Solar Observatories, Large Radio Observatories, and a Focusing X-Ray Telescope.

-- In the Physics Program, Shuttle crews will orbit a large Cosmic Ray Laboratory weighing 23 tons and revisit it yearly.

-- In the Earth Observation Program we expect our present experimental satellites like ERTS-1 to be followed by large Earth Observatory Satellites in low polar orbit (500 miles) and high synchronous orbit (22,300 miles). They will probably be three times larger than ERTS-1. Those in polar orbit will make detailed environmental, weather, oceanographic, and Earth resources surveys of the entire globe at frequent intervals. Those in synchronous orbit will be able to keep continuous watch over very large areas, such as most of North and South America, and can report on transient or short-lived environmental phenomena, such as sudden violent storms.

You may have read in the newspapers recently about the discovery of firm evidence in support of the revolutionary theory that such strange phenomena as "black holes" really do exist, and right in our own Milky Way galaxy.

This evidence was found by British astronomers in data returned from the x-ray telescopes on NASA's Copernicus satellite. The telescopes were supplied by University College, London.

I cite this recent achievement to illustrate the tremendous breakthroughs in astronomy we anticipate when the Space Shuttle and the manned Space Laboratory module are available in the 1980s.

I would also like to mention an important new kind of space activity which will be made possible by use of the Space Laboratory module. This activity is space manufacturing, which will be carried out on a commercial basis to produce a variety of valuable products which cannot be produced at all, or nearly so well, on Earth.

It has been estimated that space manufacturing may generate as much as one billion dollars worth of business per year by the end of the century. (R. R. McCreight, of the General Electric Company)

I, too, believe there will be wonderful opportunities opening up along these lines if American industrial leaders have the imagination to perceive them.

Before closing, I would like to go a little deeper into the great question of our time, the quest for extraterrestrial life. I suspect that is the part of the space program which many of you find most interesting. I will give you some personal views:

1. There is no hope of finding intelligent life elsewhere in the solar system. As far as this particular corner of the universe is concerned, we are it.

2. I do think the chances are good that we will find primitive life forms on other planets or in their atmospheres, and this will still be one of the great discoveries of all time. This discovery will shed light on how life arose on Earth. It will strengthen our conviction that intelligent life must exist on the planets of millions, or even billions, of other star systems in the universe.
3. Will we ever be able to visit other civilizations in space, or expect them to visit Earth? I am inclined to doubt it, in view of the great distances involved. We could not begin to build the kind of spaceship that would be needed. But who can say what new technologies, what new understandings of the physical laws of the universe, future generations will develop -- or hear about on the inter-galactic radio network?
4. I am very optimistic about the long-range chances of communicating by radio with very advanced civilizations in our Milky Way Galaxy or in the many billions of other galaxies in the universe.
5. When you think how many stars there are which could have planets like Earth, and how long they have been in existence, it is quite easy to believe that there must be many advanced civilizations broadcasting in our direction -- not to us specifically, but in our direction. And I am sure we have the technology needed to intercept such signals and eventually answer them.

My optimism is based on a serious study made recently with support from NASA. It is called Project Cyclops. The study comes to the conclusion that these other civilizations are indeed out there and we can hear from them if we want to make the effort.

I was particularly impressed by one paragraph in the study, and would like to share it with you. I quote:

> "To undertake so enduring a program requires not only that the search be highly automated, it requires a long term funding commitment. This in turn requires faith: faith that the quest is worth the effort, faith that Man will survive to reap the benefit of success, and faith that other races are, and have bee, equally curious and determined to expand their horizons. We are most certainly not the first intelligent species to undertake the search. The first races to do so undoubtedly followed their listening phase with long transmission epochs, and so have the later races that entered the search. Their perseverance will be our greatest asset in our beginning listening phase." End quote.

It's something to think about, but for the present we at NASA are already deeply committed to exploring here at home in the Solar System over the next two decades, and to more effective use of Earth orbit for science and practical benefits.

Now I would like to show you some slides illustrating current NASA programs, including ERTS, Skylab, and Pioneer.

I look forward to your questions after the slides.